

# ARCLITE (ARctic Lidar Technology) and Other Measurements at the NSF Sondrestrom Upper Atmospheric Research Facility near Kangerlussuaq, Greenland

Jeffrey P. Thayer (PI), John M. Livingston, Weilin Pan

SRI International, Menlo Park, CA

SOLVE II Pre-Mission Science Team Meeting

NASA Dryden Flight Research Facility

11 December 2002



# Arctic outpost operated by SRI, funded by NSF



- Facilitates access to the Arctic for research teams (**67.0N, 50.7W**)
  - The site houses over 20 scientific instruments performing arctic research
- Supports Multi-agency, cross-discipline research
  - NSF, NASA, NOAA, DOD and Danish Meteorological Institute involvement
  - Upper atmosphere and space research, middle atmosphere research, solid earth and cryosphere programs, information technology research
- Participates in National Programs
  - National Space Weather Program
  - US Global Change Research Program

# Facility instruments

Instrument	Point of Contact
Incoherent Scatter Radar (1983-)	Jeff Thayer, SRI International
Imaging Riometer (1983-)	Ted Rosenberg, Univ. of MD Peter Stauning, DMI
Allsky Imager (1983-)	Richard Doe, SRI International
Fabry-Perot Interferometer (1983-1998;2001-)	Rick Niciejewski, Univ. of Michigan
24, 30, 31 MHz Riometers (1984-)	Peter Stauning, DMI
3-axis Magnetometer (1985-)	Egil Friis-Christensen, DMI
Micro Pulsation Magnetometer (1986-)	Mark Engebretson, Augsburg College
Digisonde (1987-)	Terry Bullet, Air Force Research Lab Bodo Reinich, Univ. of Lowell
Ozone Spectrometer (1987-)	Poul Erickson, DMI
Satellite Scintillation Receiving Systems (1989-)	Santi Basu, USAF Phillips Laboratory
Spectrograph (1990-)	Abas Sivjee, Embry-Riddle Aero. Univ.
ELF/VLF Receivers (1990-1995; 2001-)	Tony Fraser-Smith, Stanford Univ.
Michelson Interferometer (1990-)	Abas Sivjee, Embry-Riddle Aero. Univ.
Rayleigh Lidar (1992-)	Jeff Thayer, SRI International
5-Channel Photometer (1996-)	Gary Swenson, University of Illinois
MF/HF Programmable Swept Frequency Receiver (PSFR) (1995-)	James Labelle, Dartmouth College
Resonance Lidar (1997-)	Jeff Thayer, SRI International Brenton Watkins, University of Alaska
Meridian Imaging Spectrometer (1997-)	Gary Swenson, University of Illinois
MF/HF Imaging Receiver (1998-)	James Labelle, Dartmouth College
Meteor Scatter Radar (1998-2000)	Susan Avery, University of Colorado
Continuous GPS Receiver (1999-)	Oivind Ruud, NCAR
GPS Receivers for Tomography (2000-)	Gary Bust, University of Texas at Austin
Simultaneous Multispectral Imager (2000-)	G. Haerendel, Max Planck Institute / Josh Semeter, SRI International
Airglow Imager (2001-)	Gary Swenson, University of Illinois
UV Spectrometer (campaigns)	Rick Niciejewski, Univ. of Michigan
UV Spectrograph (campaigns)	James Hecht, Aerospace Corporation
Auroral Photometer (campaigns)	James Hecht, Aerospace Corporation

# Incoherent Scatter Radar (ISR)

## Hardware specifications

- L-band transmitter at 1290 MHz
- 2.5-4.0 MW peak power
- 32-m fully steerable parabolic dish antenna, 0.6° FWHP beamwidth

## Measurements

- Technique measures backscattered power, Doppler shift, and spectral shape of the returned signal
- Routinely measures a variety of ionospheric parameters - e.g., electron density, electric field, conductivity, currents, energy input
- Can be operated to yield **u, v, w** wind components at altitudes 5-15 km (up to 25 km under turbulent conditions) every 30 sec



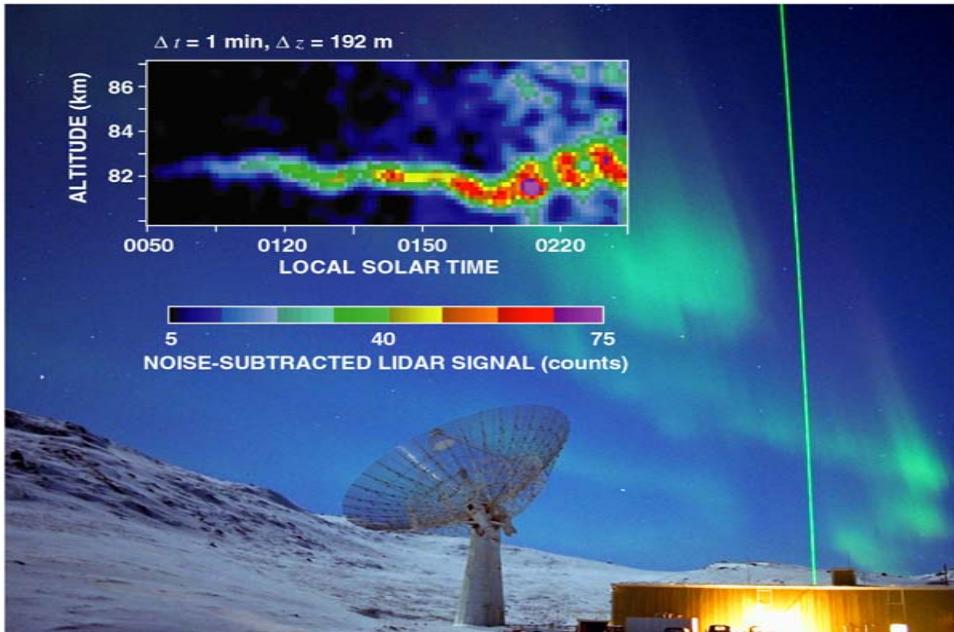
# Global change research

impact



- Designated as a primary field site within the Network for Detection of Stratospheric Change (NDSC)
  - Danish Meteorological Institute (DMI) Brewer spectrophotometer
  - **Rayleigh lidar recently designated as primary instrument within NDSC**
- DMI stratospheric ozone monitoring, lidar polar stratospheric cloud observations
- Lidar middle atmosphere temperature
- Lidar noctilucent cloud detections
- Greenland ice cap mass balance determined by GPS and gravity measurements

Optimized for middle atmospheric physics



v01-029/12

## Selected publications

Thayer, J. P., M. Rapp, A. J. Gerrard, E. Gudmundsson, T. J. Kane, " Gravity wave influences on Arctic mesospheric clouds as determined by the Sondrestrom, Greenland, Rayleigh lidar", *J. Geophys. Res.*, accepted, 2002.

Gerrard, A. J., T. J. Kane, J. P. Thayer, T. J. Duck, J. A. Whiteway, and J. Fielder, "Synoptic scale study of the Arctic polar vortex's influence on the middle atmosphere, 1, Observations", *J. Geophys. Res.*, Vol. 107, No. D16, 10.1029/2001JD000681, 2002.

Gerrard, A.J., T. J. Kane, and J. P. Thayer, "Noctilucent clouds and wave dynamics: Observations at Sondrestrom, Grenland, " *Geophys. Res. Lett.*, Vol. 25, No. 15, p. 2817, 1998.

Hecht, J. H., J. P. Thayer, D. J. Gutierrez, and D. L. McKenzie, "Multi-instrument zenith observations of noctilucent clouds over Greenland on July 30/31, 1995," *J. Geophys. Res.*, Vol. 102, No. D2, pp. 1959-1970, 1997.

Thayer, J.P., N.B. Nielsen, R. Warren, C. J. Heinselman, and J. Sohn, "Rayleigh lidar system for middle atmosphere research in the arctic," *Opt. Eng.*, Vol. 36, No. 7, pp. 2045-2061, 1997.

Thayer, J.P., N.B. Nielsen, and J. Jacobsen, "Noctilucent Cloud Observations over Greenland by a Rayleigh Lidar," *Geophys. Res. Lett.*, Vol. 22, No. 21, pp. 2961-2964, 1995.

# ARCLITE Facility

specifications

## System hardware

- Rayleigh/Mie lidar: Nd:YAG laser 532 nm, 30 Hz, 560 mJ, daytime capable
- Resonance lidar: dye laser 589 nm, 10 Hz, 100 mJ, twilight capable
- Receiver: Newtonian telescope configuration, 92-cm diameter telescope, 2 channels
- Signal Processing: photon counting with 48-m range bin resolution, 4096 bins

## Measured atmospheric parameters

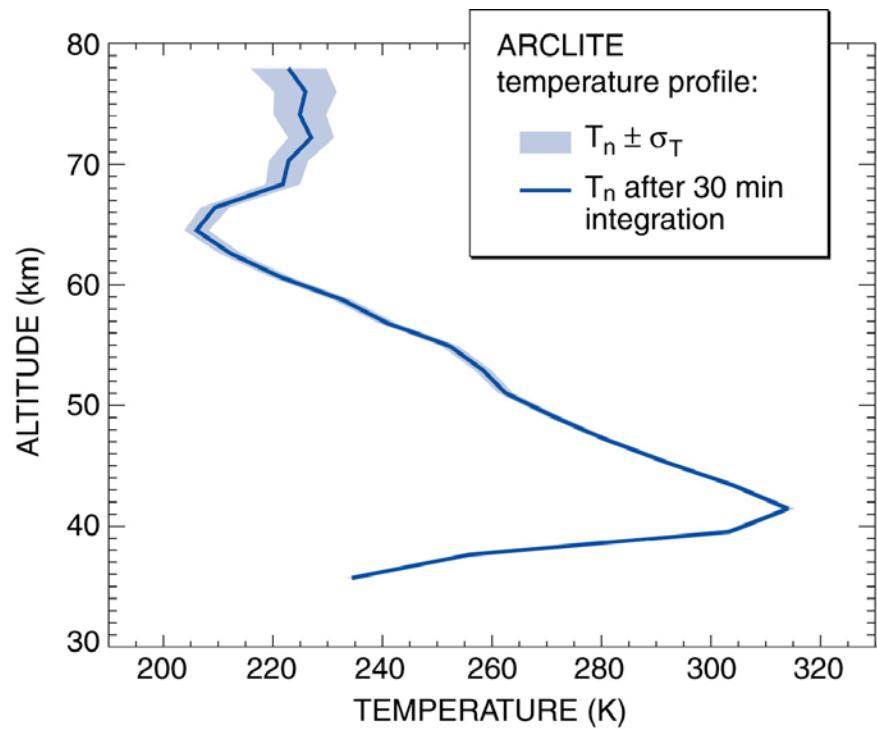
	Rayleigh Lidar (since 1992)		Resonance Lidar (since 1997)	
Parameter	Altitude Coverage*		Altitude Coverage*	
	Present	SOLVE II	Present	SOLVE II
Neutral Density	30-90 km	25 <sup>a</sup> -70 km	30-55 km	25 <sup>a</sup> -45 km
Temperature	30-80 km	25 <sup>a</sup> -60 km	30-45 km	25 <sup>a</sup> -35 km
Aerosol Backscatter Ratio	30-90 km	10-70 km	20-55 km	10-45 km
Gravity Wave Energy	30-55 km	25 <sup>a</sup> -35 km	85-105 km	
Sodium Density			85-105 km	

\* based on 30-min average

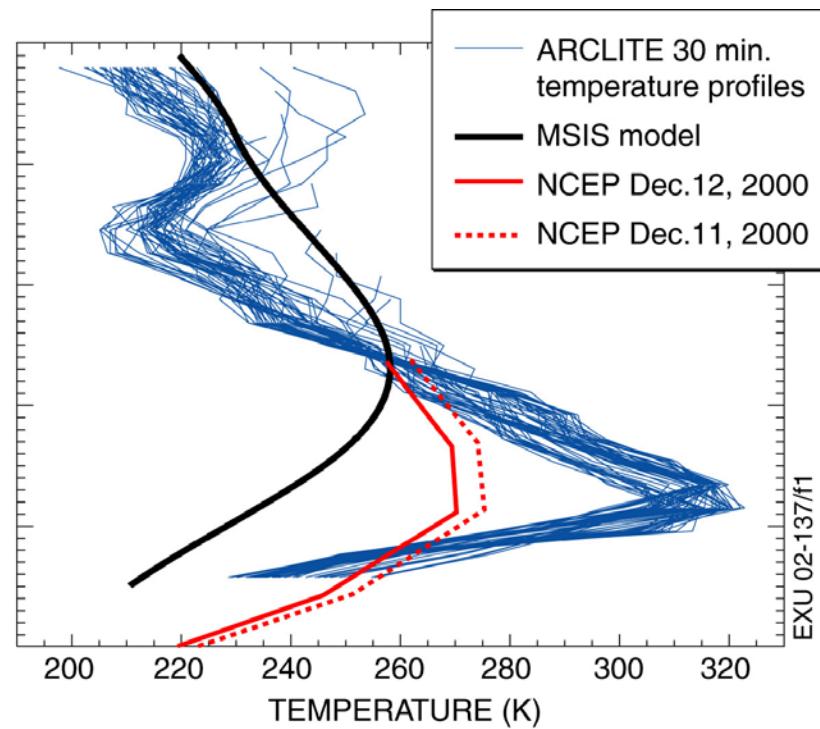
<sup>a</sup> lower altitude limit determined by aerosol profile

## Upper Stratospheric Temperature Extrema Event

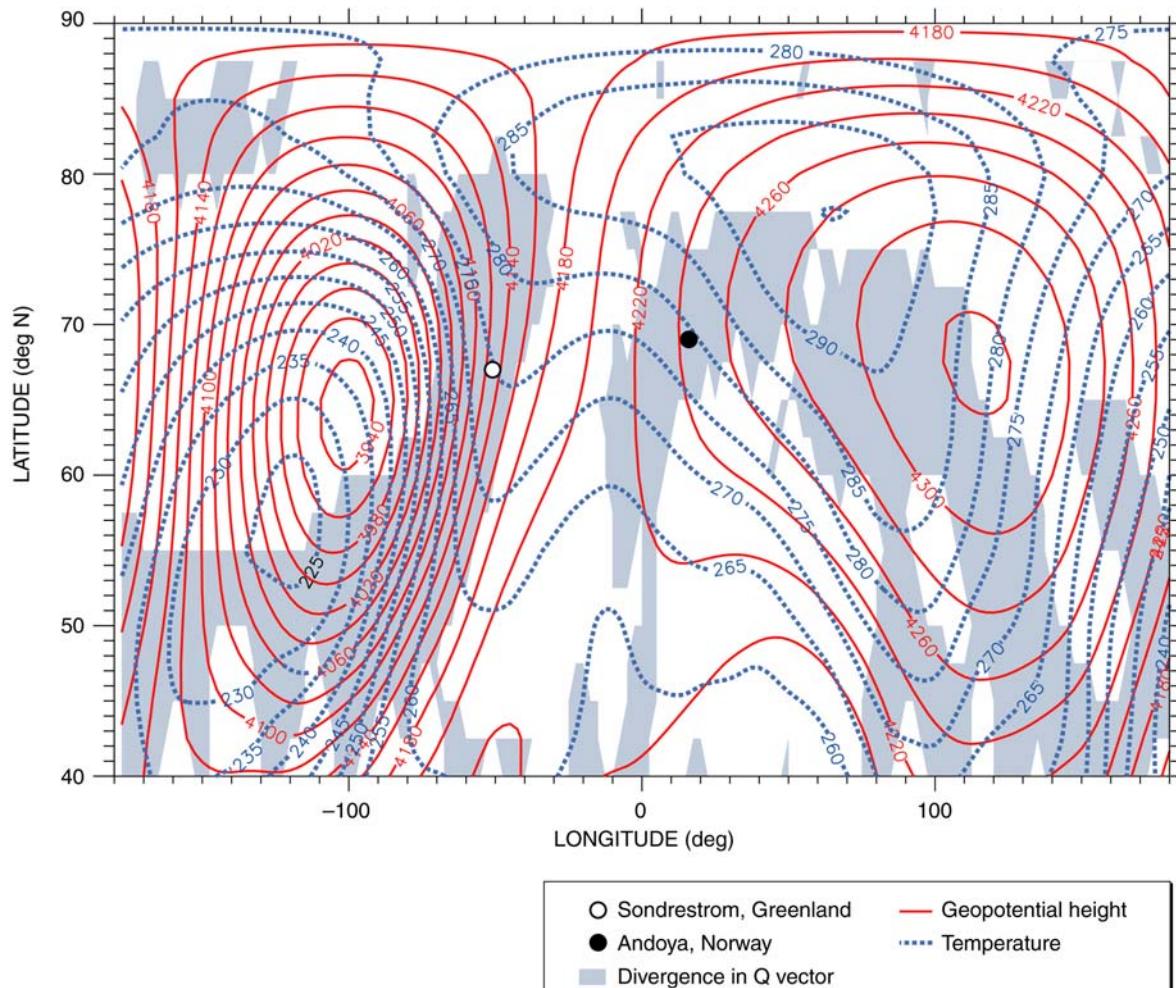
1815-1845 UT Dec. 12, 2000



1715 UT Dec. 11 – 2358 UT Dec. 12, 2000

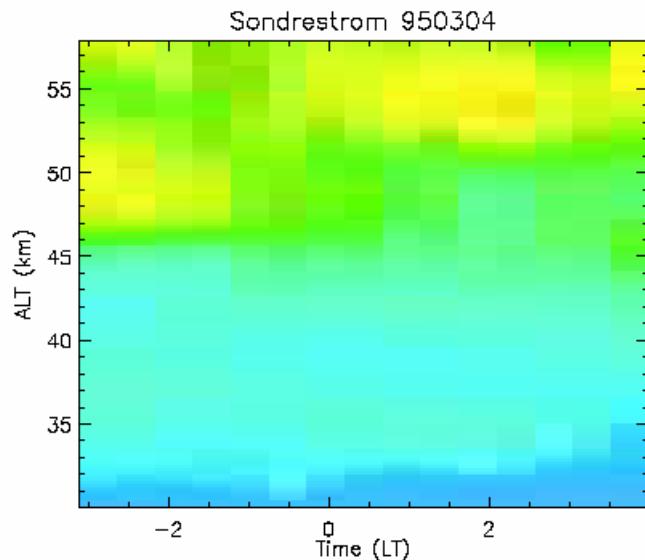


## NCEP Analysis at 2 hPa for 12 UT December 12, 2000

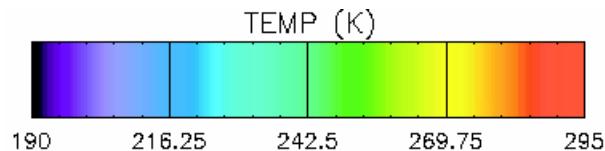
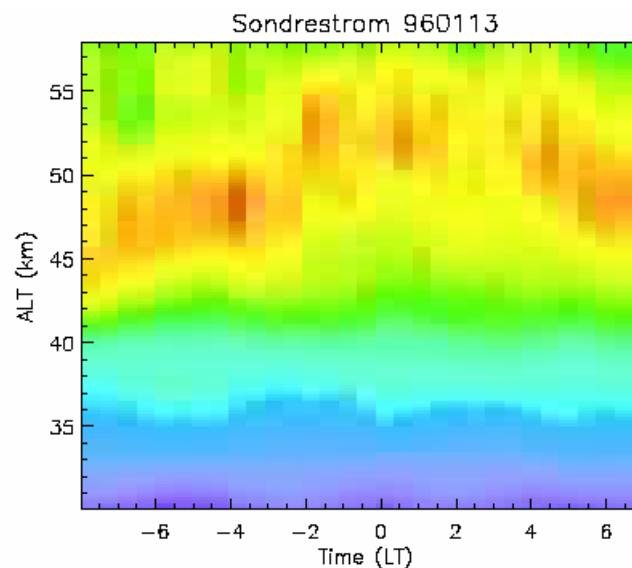


## Time Series of Temperature Profiles

vortex jet



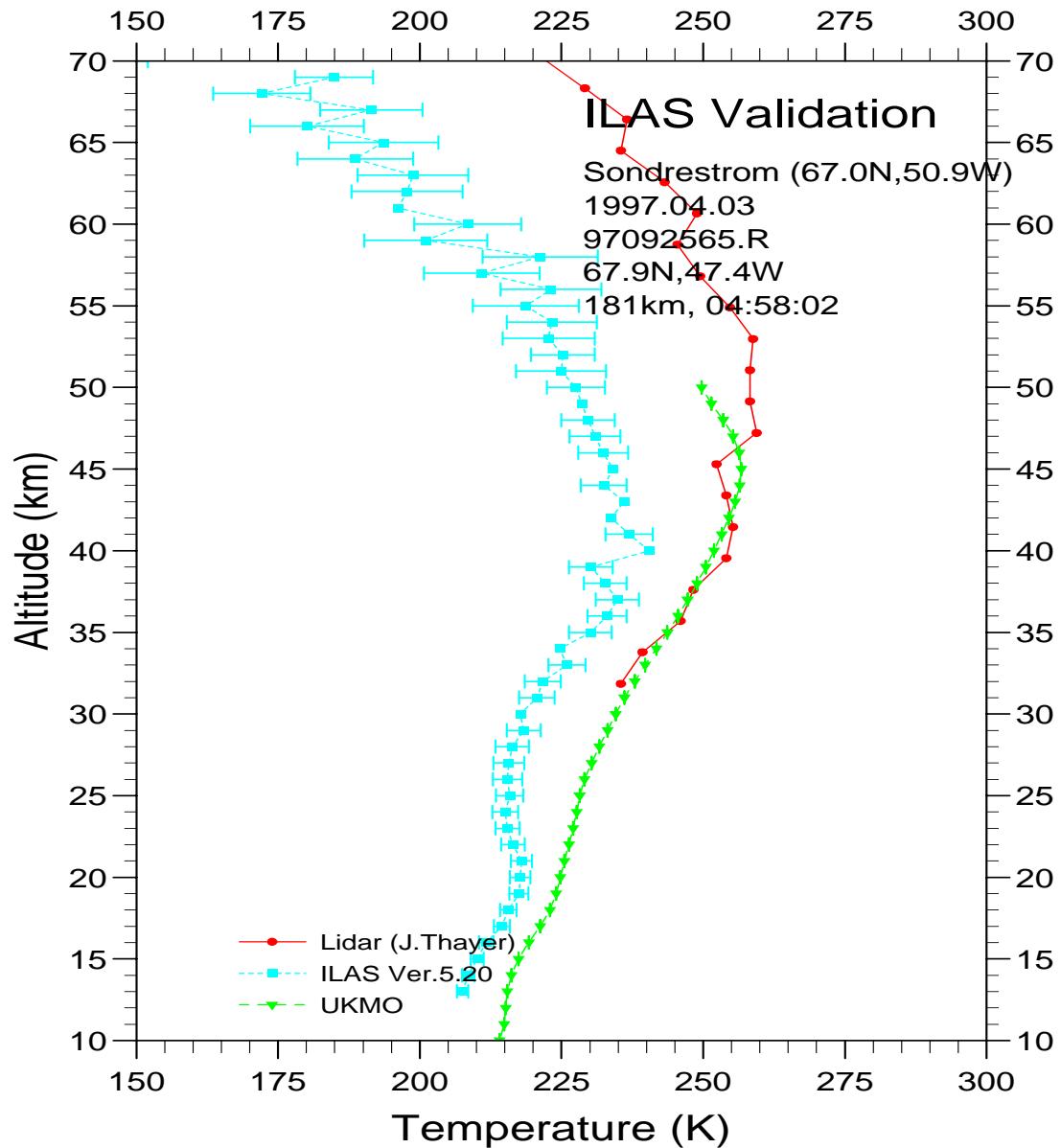
vortex inner jet/core



Gerrard, A. J., T. J. Kane, J. P. Thayer, T. J. Duck, J. A. Whiteway, and J. Fielder, "Synoptic scale study of the Arctic polar vortex's influence on the middle atmosphere, 1, Observations", *J. Geophys. Res.*, Vol. 107, No. D16, 10.1029/2001JD000681, 2002.

# ARCLITE Measurements

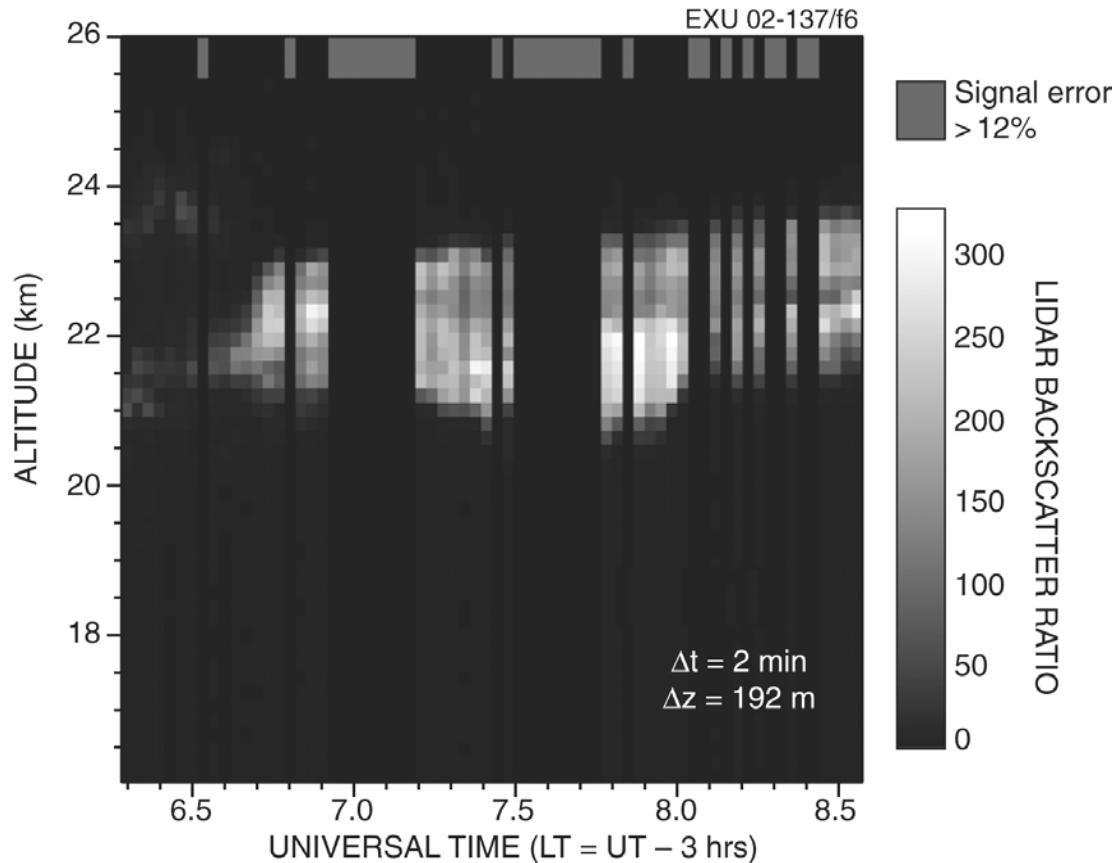
## Validation of satellite temperature retrievals



Slide provided by  
Dr. Takafumi Sugita

Polar stratospheric cloud characterization

## Polar Stratospheric Cloud: 19 Feb 1996



Thayer, J.P., N.B. Nielsen, R.E. Warren, C.J. Heinselman, and J. Sohn, "Rayleigh lidar system for middle atmosphere research in the arctic," *Opt. Eng.*, Vol. 36, No. 7, pp. 2045-2061, 1997.

## SOLVE II Science Objectives Addressed by Sondrestrom Facility

---

- Investigation of polar vortex dynamics
- Validation of SAGE III temperature retrievals
- Characterization of PSCs/orographic forced waves using lidar aerosol backscatter and ISR-measured winds
- Comparison of vertical profiles of aerosol backscatter and temperature with DC-8 lidar measurements

## Proposed ARCLITE Augmentation

---

- Improve aerosol backscatter measurements in the lower stratosphere (5-30 km)
- Extend temperature measurement to the lower stratosphere (5-30 km) using nitrogen Raman technique
- Improve PSC/aerosol characterization by adding depolarization technique
- Proposal submitted to NSF in August 2002

<http://isr.sri.com/>



## **DATALINK**

- Real time data links to instruments at Sondrestrom
- ISR operations
- Library of data

Sondrestrom  
**►Site COORDINATES**

## **Education & OUTREACH**



High school students from Colorado visit Sondrestrom and help run experiments.  
[More...](#)



Auroral studies shed light on the physics of space and provide valuable information about global change ([from](#)

## Sondrestrom **Research News**



[\*\*Topical collection\*\*](#) in JGR  
Atmospheres on Layered Phenomena of the Mesopause Region

AUGUST 2002 Search for Naturally Enhanced Ion Lines inconclusive. More investigations to be made.

APRIL 2002 World day storm shows large Joule heating event

JANUARY 2001 ISR/optical detection of cusp, led by [Pallamraju Duggirala](#), Boston U.

## Sondrestrom **Site News**

**October**  
2002

SMI system routinely operating during clear and active conditions.

<http://isr.sri.com/instruments/data/arclite/arclite.html>